

Notes on the Rediscovery, Status, and Ecology of the Very Rare Hawaiian Fern *Christella boydiae* (Thelypteridaceae)

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The genus *Christella* (Thelypteridaceae) is comprised of approximately 50 species distributed predominantly in the Old World tropics but also in the Americas (Holttum 1977). Two native *Christella* species, *C. cyatheoides* (Kaulf.) Holttum and *C. boydiae* (Eaton) Holttum occur in Hawai'i (Wagner, 1981). *Christella cyatheoides* is a common and characteristic component of matted fern understory of Hawaiian rain forest. *Christella boydiae* is a much rarer diminutive species of rocky stream courses. *Christella boydiae* has been collected only from the Ko'olau range of O'ahu, Kipahulu and Waiho'i Valleys on East Maui, and along low elevation watercourses near Hilo on Hawai'i. Currently it is only known from one of these historic populations at Kipahulu Valley.

There are 20 specimens of *C. boydiae* in the Bernice Pauahi Bishop Museum Herbarium Pacificum (BISH) that represent 18 or fewer collections. Most of these specimens are in poor condition and as typical of collections made prior to 1910, have little or no collection information. The species has been most often collected on O'ahu. Of these, six specimens (one third of the total at BISH) were made between 1900 and 1908 by either of the noted Hawaiian botanists, C.N. Forbes or J.F. Rock, mostly from the Punalu'u region of the Ko'olau range. The last collection of *Christella boydiae* on O'ahu was made prior to 1908. However, Warren H. Wagner found that this species was still present in the Punalu'u area of the Ko'olau range on O'ahu as late as 1965 (Kaluanui Stream, rock shelves, Castle trail, Hau'ula Forest Reserve, Ko'olau range, W. H. Wagner and S. Carlquist 65270 MICH). Since that time, many exotic weeds, notably *Clidemia hirta* (Melastomataceae), have invaded the area and this species has apparently disappeared. On Hawai'i island, the species, to our knowledge, has been collected only once. Until recently, *Christella boydiae* had been collected only three times on Maui, first in 1881 in Kipahulu Valley (F.L. Clarke s.n., BISH) without further location information. Then after 86 years, *C. boydiae* was again collected in Kipahulu Valley in 1967 (R. DeWreede 30) along Palikea stream at 915m (Lamoureux, 1968). A third Maui collection was made in 1973 in adjacent Waiho'i Valley as part of the NSF-sponsored Waiho'i Valley Research Project (B. Harrison 10) at 915-1040 m along Waiohonu stream where it was a rare fern from a shady location under a ledge associated with hymenophyllaceous ferns and various mosses along the stream bank (B. Harrison-Gagne, pers. comm.). Neither of these collections is present in the cabinets at the Herbarium Pacificum (BISH): although the latter is in the University of Hawai'i collection. Fourteen specimens at the Herbarium Pacificum (BISH) include the year of collection. Of these, eight were collect-

ed before 1900 and six between 1900 and 1908. No collection of *C. boydiae* in the Herbarium Pacificum was made after 1908.

In 1985, *Christella boydiae* was rediscovered along streambeds in middle Kipahulu Valley, Haleakala National Park. Botanical specimens collected as part of baseline vegetation work were identified as *Christella boydiae* by Wagner from the University of Michigan while a visiting professor in Hawai'i in 1987. Based on subsequent field work, this species is now known from the three primary periodic watercourses of Kipahulu Valley at 1160–1500 m (A.C. Medeiros 795, R.W. Hobdy & A.C. Medeiros 2834 through 2847, BISH). Currently, 146 plants in six populations are known from Kipahulu Valley. Of these, 12 occur in one population on Koukouai stream, 16 in one population in a tributary of Palikea stream and 118 plants in four populations along the unnamed central valley stream. The populations of *C. boydiae* found in Haleakala National Park are the only ones known, though it may also occur outside the Park in adjacent Waiho'i Valley. The large remote tracts of stunted rain forests and stream courses in Waiho'i Valley contain substantial populations of alien plant species and semi-domestic cattle and feral pigs.

In Kipahulu Valley, *Christella boydiae* occurs on exposed, rocky, moss-covered banks of periodic stream courses in dense *Metrosideros* or *Metrosideros* and *Acacia* rain forest with a thick matted fern understory. *Christella boydiae* is a small rosette fern that grows in rock crevices and along rocky ledges mostly at, or just above, high water level. The species grows in near full sunlight and seems to avoid habitats where there is competition for space from taller species. Most plants are less than 0.25 m in height and with their small stature, any amount of such competition would result in overtopping. In winter storms, these stream courses are subject to flooding that scour the banks with high water, logs and debris. Annual rainfall in this area is approximately 250 inches (6250 mm). Although dense mist and clouds are frequent, extended periods of sunny clear weather also occur, primarily in summer. Associated native species include the ferns *Athyrium microphyllum*, *Amauropelta globulifera*, *Asplenium unilaterale*, *Christella cyatheoides*, and *Sadleria pallida*, the graminoids and forbs *Carex alligata*, *Deschampsia nubigena*, and *Pilea peploides* and the dwarfed woody species, *Broussaisia arguta*, *Clermontia arborescens*, *Metrosideros polymorpha*, and *Vaccinium calycinum*. Alien species on the stream banks include *Deparia petersenii*, *Holcus lanatus*, *Hypochoeris radicata*, and *Prunella vulgaris*.

According to the scanty record afforded by herbarium specimens, *Christella boydiae* was formerly found along streams down to very low elevations but by the 1920s had disappeared from much of its range and entirely from lower elevation habitats. The type collection of this species was made on O'ahu at 30 m elevation (Eaton, 1879). Robinson (1913) cited the habitat of his species as "on rocky ledges, along streams." Hillebrand (1888) states, "On bare rocks in the bed of Wailuku river, Hilo, Hawaii, where the ordinary sized form grows along the banks . . . Found also by Baldwin under the same conditions by the side of a stream in Koolau, Oahu." *Christella boydiae* was described from O'ahu as *Aspidium boydiae* Eaton (Eaton, 1879). Hillebrand (1888) considered it a dwarfed form of the more common native species *Christella cyatheoides* (known then as *Aspidium cyatheoides*), reduced it to a variety of that taxon (var. *depauperatum* Hillebr.), and reported the distribution as O'ahu and Hawai'i. Robinson (1913) restored this taxon to species level but in a separate genus, *Cyrtomium boydiae* (Eaton) Robinson, based on the presence of peltate indusia. Iwatsuki (1964) assigned the species to the genus

Table 1. Morphological comparison of *Christella boydiae* and *C. cyatheoides*, based on specimens of the two species collected from Kipahulu Valley, East Maui.

Character	<i>C. boydiae</i>	<i>C. cyatheoides</i>
1. Sori	medial on vein impressed below, embossed above	basal on vein surface smooth above and below
2. Indusia	peltate, 1.0–1.5 mm diam. reniform, 1.0 mm diam.	
3. Scales	absent on leaf axes	abundant on rachis and costa
4. Glandular hairs	absent	moderate to abundant below; yellowish
5. No. of layers of anastomosing veins	usually 1, sometimes 2	usually 4–6, sometimes 3–8
6. Fertile frond length	6–32 cm	20–200+ cm
7. Pinna dimensions	13–40 mm long, 5–8 mm wide	70–210 mm long, 15–28 mm wide
8. Pinna margins	crenate	strongly crenate to lobed, 1/2 way to costa
9. Pinna apices	rounded to acute	acute to acuminate
10. Pinna bases	cuneate on prominent 1–3 mm stalks	truncate to cordate; on inconspicuous 1–2 mm stalks

Thelypteris as the sole representative of the subgenus *Cyrtomiopsis*. Holttum (1976) placed the species in *Christella*, a segregate of *Thelypteris*. Other authorities place the species in the large more inclusive genus, *Thelypteris*.

Due to the rarity of this taxon in the field and the consequent sparsity of herbarium collections, even recent workers have been cautious in recognizing *Christella boydiae* as distinct from the other Hawaiian species, *C. cyatheoides*. Holttum (1977) states, "Hillebrand considered this to be a depauperate form of *Christella cyatheoides*; I agree that they are allied, but think it possible that *C. boydiae* is distinct, as its scales appear to differ. Plants should be cultivated, to see what size they will attain and for a careful comparison with living plants of *C. cyatheoides*." The two Hawaiian *Christella* species are easily distinguished and when more closely examined are marked by a number of characters that clearly separate them (Table 1). In addition, *Christella cyatheoides* is a much larger fern that grows in the dense matted fern understory of Hawaiian rain forests. It is also commonly pendant along the sides of watercourses. Dwarfed individuals of *C. cyatheoides* also occur in rocky areas of stream courses. However, despite the suggestion of earlier taxonomic literature, even stunted individuals of *C. cyatheoides* are easily distinguished from *C. boydiae* (Table 1). Both species occur side by side in Kipahulu with no signs of F_1 hybridization or introgression.

The disappearance of *C. boydiae* may be due to the dense growth of alien plant species that now occupies many lower elevation stream courses. Species such as *Ageratina adenophora*, *Deparia petersenii*, *Brachiaria mutica*, and *Melinis minutiflora* are now dominant species in low elevation habitats where formerly *C. boydiae* occurred. The invasion of riparian habitats by alien weeds in the relatively high elevation stream courses of Kipahulu Valley that are the last known refuge for *C. boydiae* may be the primary threat that may affect its long-term survival. Stream courses with their high light intensi-

ties and frequent disturbance are prone to invasion by alien species, even in otherwise relatively intact Hawaiian natural areas.

Despite its rarity, *Christella boydiae* has a Hawaiian name, *kupukupu-makali'i*, literally the "small-eyed *kupukupu* fern" (Pukui & Elbert, 1986). The name *kupukupu* is usually applied to the fern *Nephrolepis*, the word *makali'i* meaning "small-eyed" presumably in reference to the conspicuous, round sori of *C. boydiae*. Early Hawaiians named the other native *Christella* species, *C. cyatheoides*, *kikawaio*; young fronds and roots were used for food and medicine (Pukui & Elbert, 1986).

In comparison to many other rare species in Hawaiian ecosystems, the possibility for long term conservation of this species appears good. At least there is active management ongoing to perpetuate the survival of native species and ecosystems. The known populations of *Christella boydiae* and the alien weeds that are present are being monitored.

ACKNOWLEDGEMENTS

We thank Betsy H. Gagne for information regarding Waiho'i populations, Lloyd L. Loope for reviewing this work, and David W. Miranda and Ronald J. Nagata, Resources Management, Haleakala National Park for assistance with field work.

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